# The Future of NASA's Space Communications

National Aeronautics and Space Administration


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Maryland Space Business Roundtable
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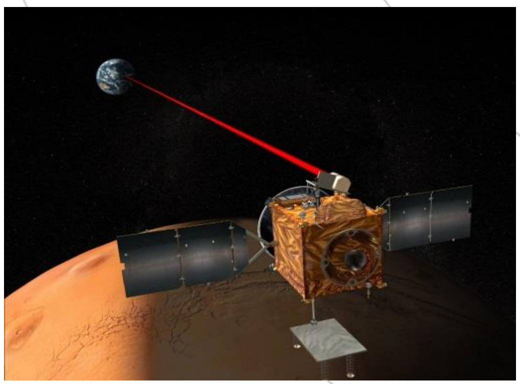
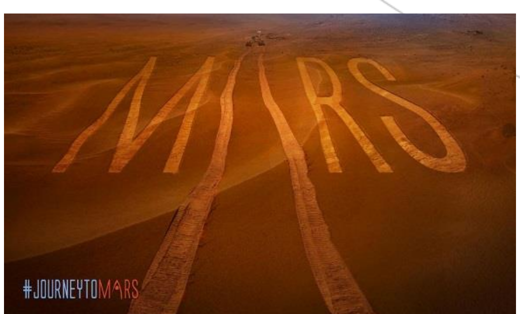
www.nasa.gov

# SCaN is Responsible for all NASA Space Communications






- Responsible for Agency-wide operations, management, and development of all NASA space communications capabilities and enabling technology.
- Expand SCaN capabilities to enable and enhance robotic and human exploration.
- Manage spectrum and represent NASA on national and international spectrum management programs.
- Develop space communication standards as well as Positioning, Navigation, and Timing (PNT) policy.
- Represent and negotiate on behalf of NASA on all matters related to space telecommunications in coordination with the appropriate offices and flight mission directorates.

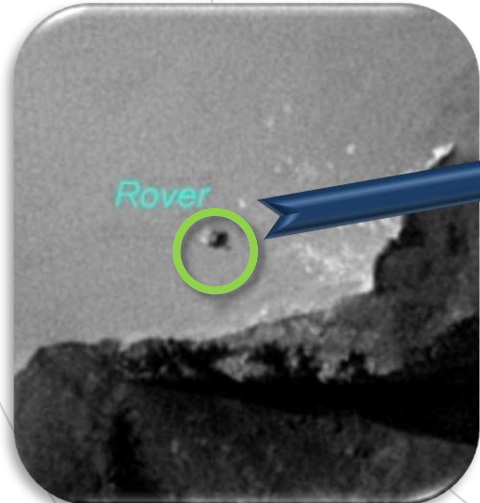
# NASA Networks Span the Globe


Deep Space Network Near Earth Network Space Network

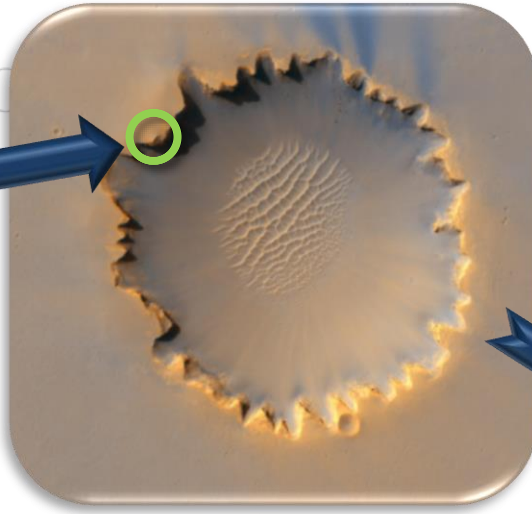

Mars Exploration in This Decade
Operational 2001-2012
2014
2016
2018
2020
2022
Odyssey
MRO
ESA Mars Express
MAVEN Aeronomy Orbiter
ESA Trace Gas Orbiter (Electra)
Habitable Environments
Seeking Signs of Life
Future Planning
Opportunity
Curiosity Mars Science Laboratory
InSight Lander
ESA ExoMars Rover (MOMA)
2020 Science Rover

# Challenges for Mars Exploration

## NASA Science Needs Faster Download Data Rates…




Picture of a Mars Rover taken at one-foot resolution



…at Victoria Crater

…on Mars

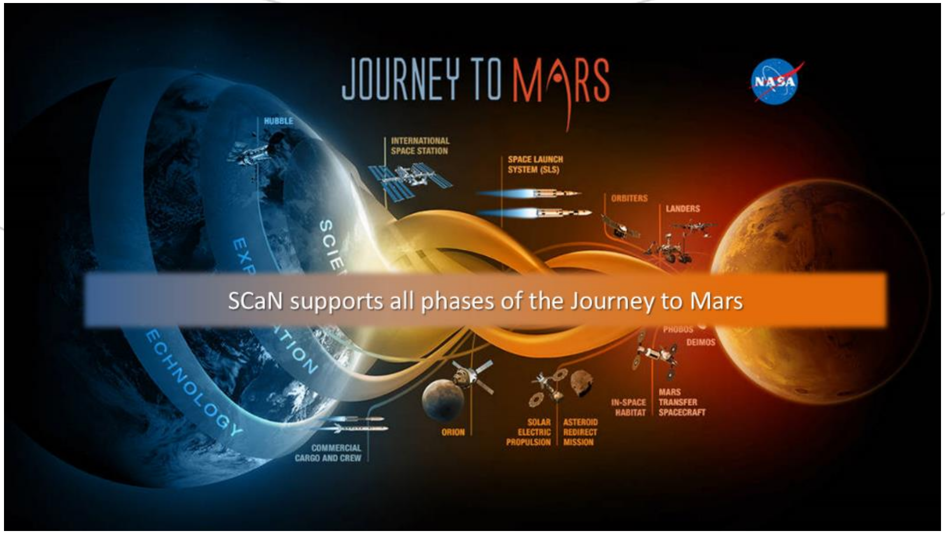
To transmit a one-foot resolution "Google" map of the entire Martian surface:

- Best radio frequency system would take 9 YEARS!
- Optical comm can do it in 9 WEEKS!

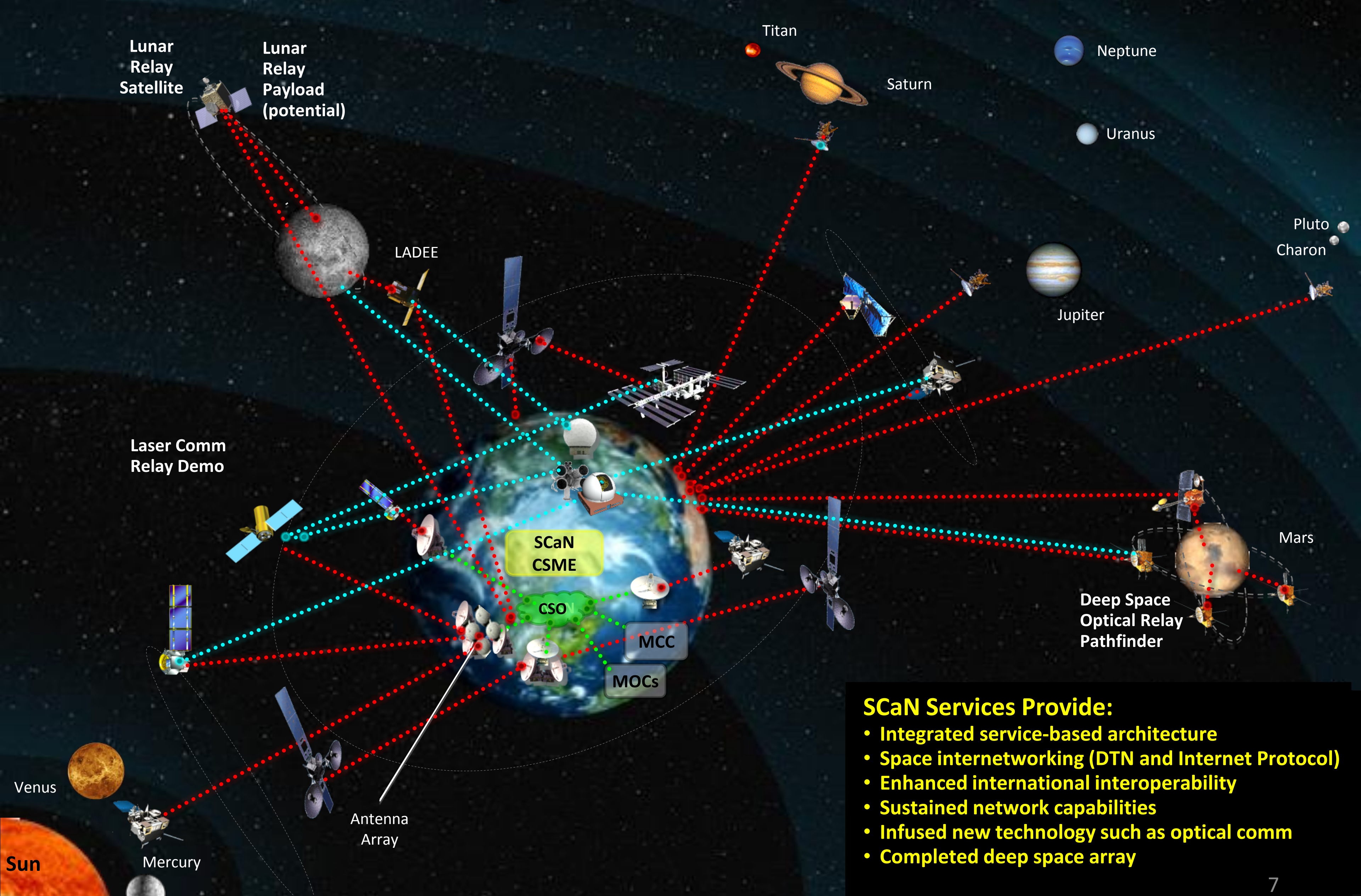
**OPTICAL COMM'S HIGHER DATA RATES CAN BREAK THROUGH TODAY'S SCIENCE DATA BOTTLENECK**

# NASA's Journey to Mars

- SCaN's path for enabling the human exploration of Mars has already started
  - The Space Network provides 24x7 communication and tracking services to the International Space Station, including its experiments
  - The Space Network provided continuous communications and tracking services to Orion during its inaugural flight in December
  - Launch Communications Stations: multi-user ground stations using NASA and US Air Force stations and cooperative agreements currently under construction
  - Building capabilities to support EM1 and EM2, as well as the Asteroid Redirect Mission
  - Evolving far less burdensome, but more capable Comm. and Nav. Technology
  - SCaN is developing capabilities (optical communications) that will allow humans on Mars to communicate at a high data rate with the ground stations on Earth
- SCaN will be there to enable NASA journeys to Mars and to ensure that humans are sent and returned safely



# SCaN Notional Integrated Communication Architecture



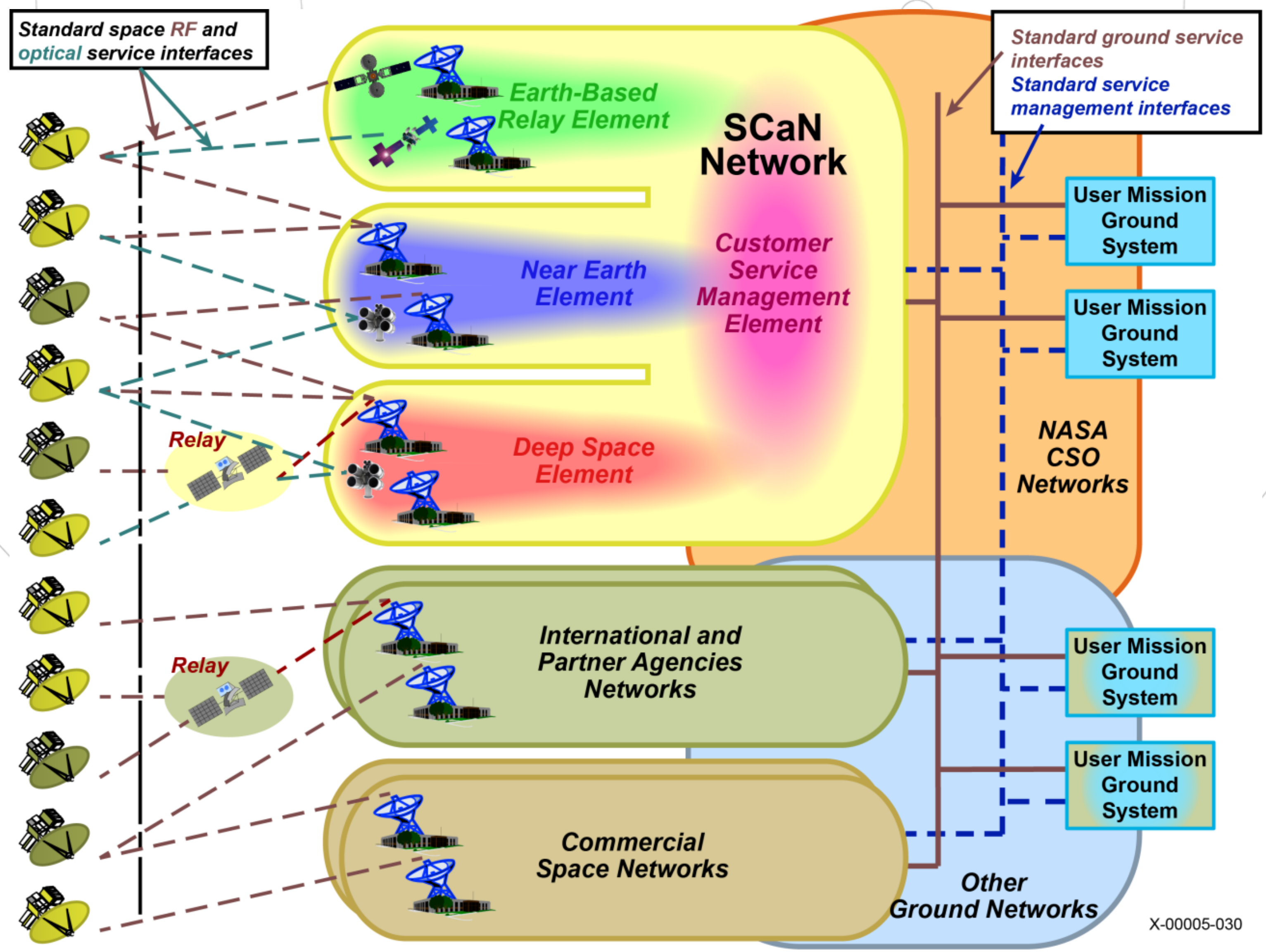

## SCaN Services Provide:

- Integrated service-based architecture
- Space internetworking (DTN and Internet Protocol)
- Enhanced international interoperability
- Sustained network capabilities
- Infused new technology such as optical comm
- Completed deep space array

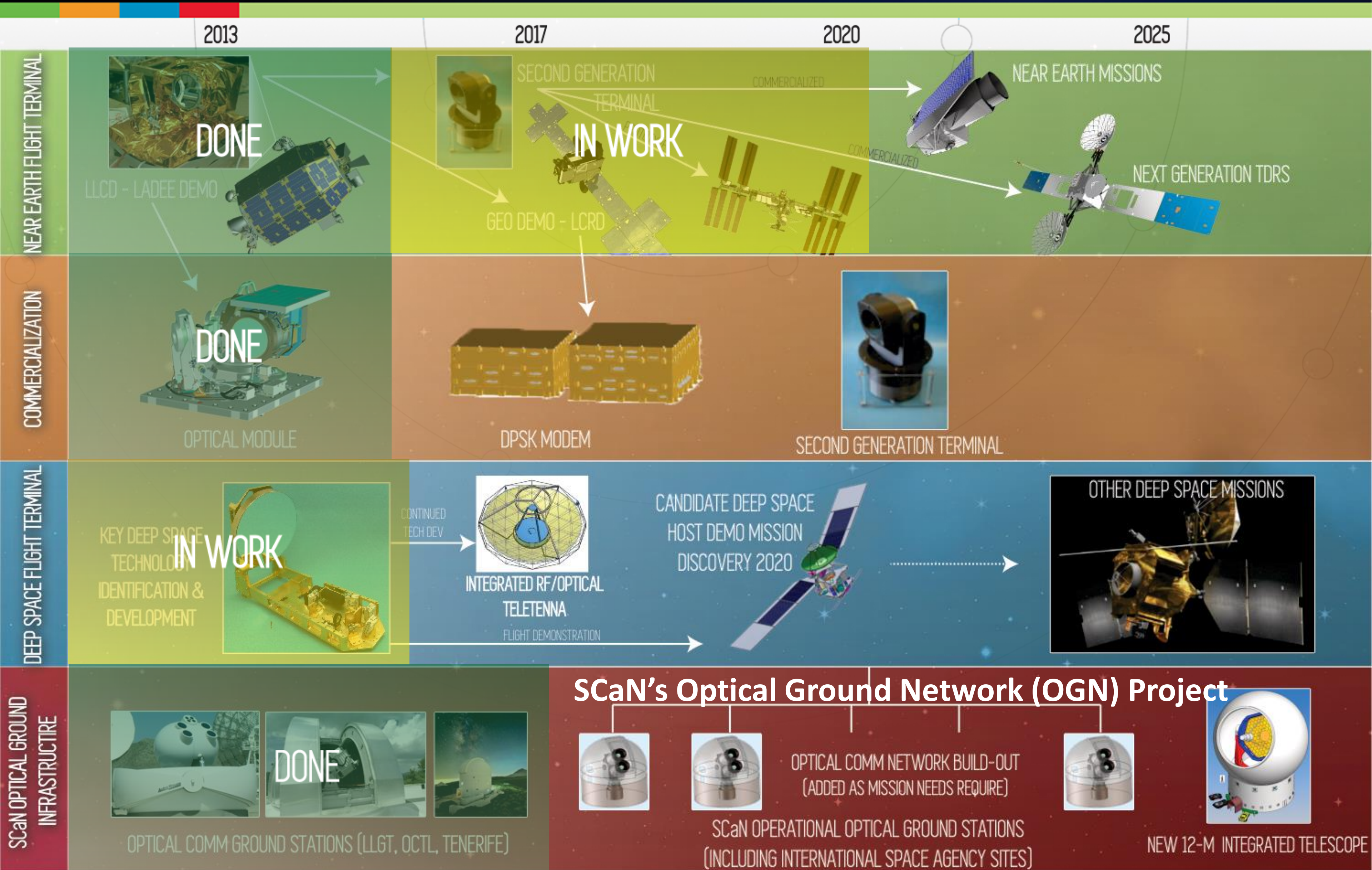


Microwave Links | Optical Links | Communications Service Office (CSO)

# Moving towards International Interoperable Services



# An Enabling Technology: Optical Communication



# Optical Communication Demo and Follow-on: LLCD and LCRD

- Space Technology Mission Directorate/SCaN Mission
- Commercial spacecraft host (Space Systems Loral)
- Flight Payload
  - Two LLCD-heritage Optical Modules and Controller Electronics Modules
  - Two Differential Phase Shift Keying (DPSK) Modems with 2.88 Gbps data rate
  - New High Speed Electronics to interconnect the two terminals, perform data processing, and to interface with the host spacecraft
- RFI for “Guest Investigators” revealed significant commercial interest
- Key for Next-Gen TDRS (or equivalent) in 2024 timeframe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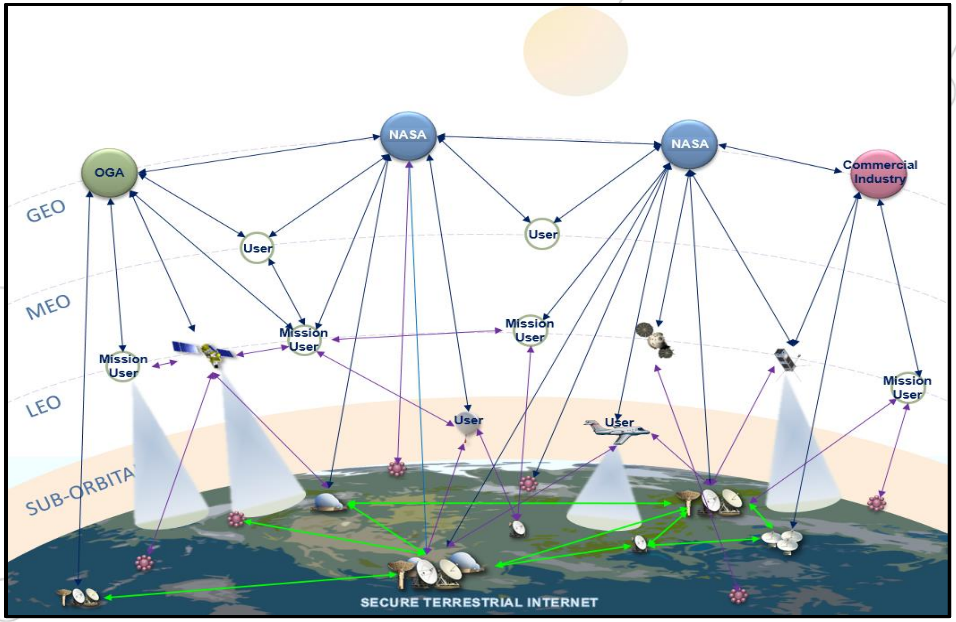
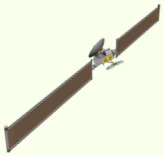
# Pursuing Additional Enabling Technologies

- **Objectives:**
  - Infuse advanced technologies into relay, user terminals, ground terminals and integrated network management to increase capacity and connectivity and reduce total system costs
- **State of the Art Comparison:**
  - 20th Century TDRS vs. Transformational Space Network with multiple beam antennas, unscheduled demand access, onboard processing switching and routing, inter-satellite links, direct data distribution, autonomous network operations, and global connectivity
- **Benefits:**
  - Significantly higher capacity
  - Optimal use of available capacity
  - Unscheduled access service
  - First use of Ka SA service
  - Widespread use of Ka-band SGLs
  - Flexibility to reconfigure
  - Internet-like connectivity
  - Reduced costs through automation
- **Beneficiary:**
  - Missions: higher capacity, greater connectivity, lower cost
  - US Industry: increased global competitive advantage

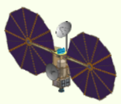



DRAFT – Conceptual Next Generation Near Earth Architecture

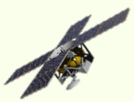
# Mars Network Architecture Exploration and Science: Notional Evolution Path Options



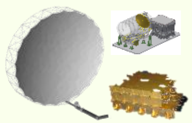
Dedicated Launch:
Large Orbiter
- *Full Service*



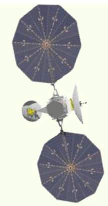
Secondary Launch:
Small Orbiter
- *Lower Performance*



Carried to Mars:
Small Orbiter
- *Reduced Service*



Contributed Hardware Components

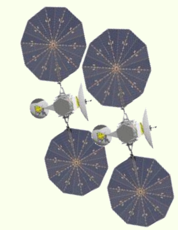


"DSN at Mars"
Areostationary Orbiter
- *Trunk line*

**- And/Or -**

Low/Mid Altitude Relay Orbiter
- *Links to high latitudes*

Science/Relay Orbiter
- *Ad-hoc relay links give redundancy (Augmentation)*



"DSN at Mars"
2-3 Areostationary Orbiters
- *Up to continuous degree coverage: 70 S-70 N*

Polar Relay Orbiters (~2)

Science/Relay Orbiters (Ad-hoc) (Augmentation)

## Early-Mid 2020s: Demo and Early Mission Ops Options

- Partner with SMD on next Mars orbiter
- Demo early technologies
- Backwards compatible services for legacy missions
- Transitioned to SCaN leadership of network operations

## Late 2020s: Early Partial Network

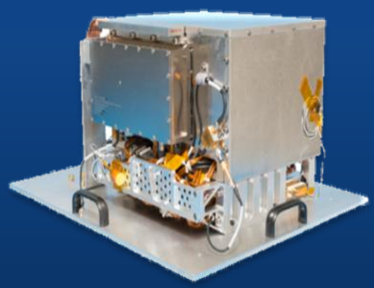
- Enhance limited coverage
- Infuse early technologies
- Demo mid-term technologies
- Complete transition to SCaN network operations

## 2030s: Full Mars Network

- Expand coverage
- Limited Mars positioning system
- Infuse mid-term technologies
- Support human and science missions

# New Technologies

## Deep Space Atomic Clock

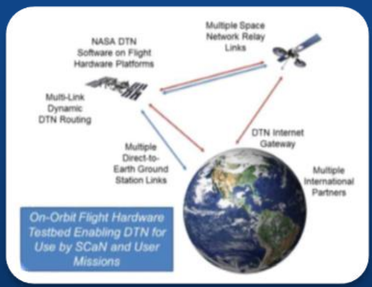


- Precise navigation with radio communication is key in determining a spacecraft's location in deep space, but the clocks tend to drift over time. ***DSAC is 100X more stable than current space clocks***
- Smaller and less range error than other space clocks
- Perform year-long demonstration in space around mid-2016

## Cognitive Radios

- After technology is launched into space, it's difficult to make modifications or upgrades from the ground.
- Cognitive systems sense, detect, classify, and adapt to time-varying communication environment to optimize data throughput.
- On orbit testing around 2017

## Disruption Tolerant Networking




- Communicating in the space environment is not as direct as here on Earth and involves a lot of outages and stops.
- Designed to work in environments where end-to-end paths may not be available
- Testing on various platforms since 2008

# Partnerships and Collaborations

## Government Agencies

- Working with agencies on mission support, spectrum and navigation policies
- NOAA, State Department, FCC, NTIA, DOT

## Academia/Industry

- Quantum Entanglement, Laser Communications Relay Demonstration (LCRD), SCaN Testbed

## International

- Cross support and compatible interoperability architectures including standards and spectrum policy and regulatory issues
- Interoperability Plenary, Interagency Operations Advisory Group, Space Frequency Coordination Group, International Committee on GNSS

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*Keeping the Universe Connected*